Armed Forces College of Medicine

AFCM

cerebellum physiology

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

- Distinguish the mechanism of ballistic movement
- Recognize the role of the cerebro-cerebellum and its afferent and efferent connections in voluntary movement control
- Explain the role of cerebellum in control of equilibrium & muscle tone.
- Recognize the non- motor functions of cerebellum in learning

Lecture Plan

- Spinocerebellar functions (15 min)
- Cerebrocerebellum functions (15 min)
- Role of climbing and mossy fibers (10 min)
- Summary (10 min)
- Lecture Quiz (5 min)

Spino-cerebellum functions

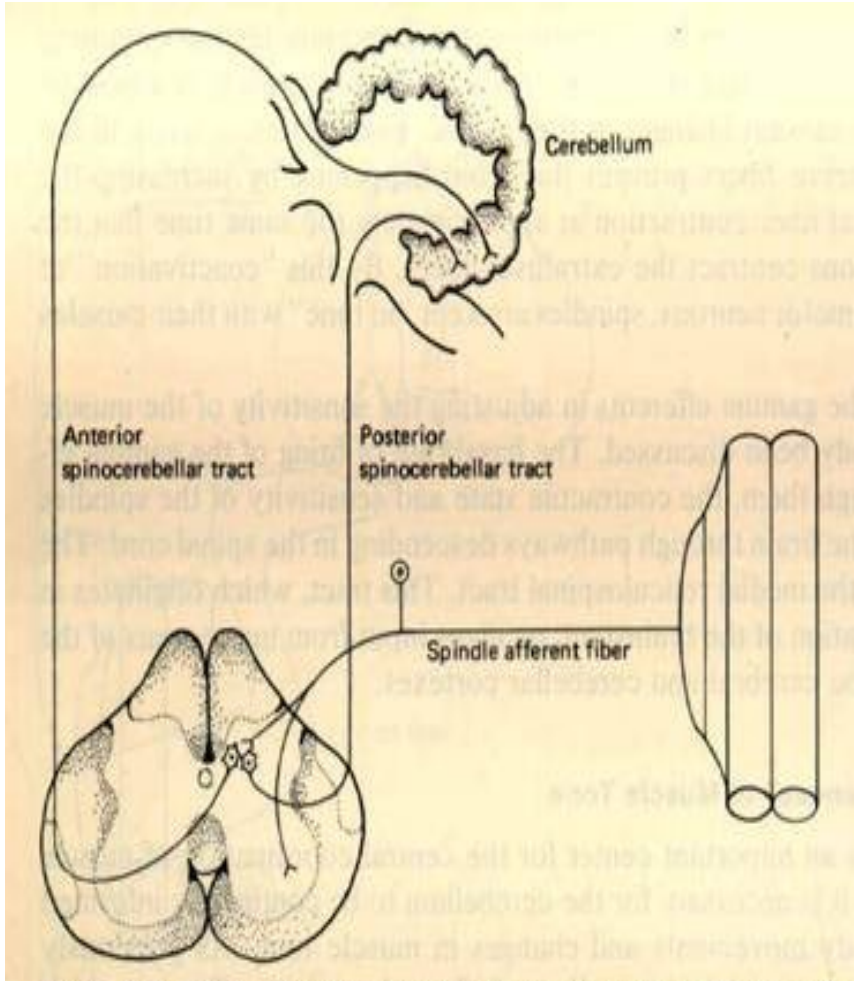
Coordinate the ongoing movement

- servo-compartor function
- Damping function
- ballistic movement

B - Damping function:

Mechanism:

increasing the stretch reflex sensitivity in the antagonistic muscle during movements. {cerebellar stretch reflex}



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C - Coordination of rapid ballistic movements :

Rapid movements preplanned to go to specific time then stops as fingers typing or saccadic eye movements during reading.

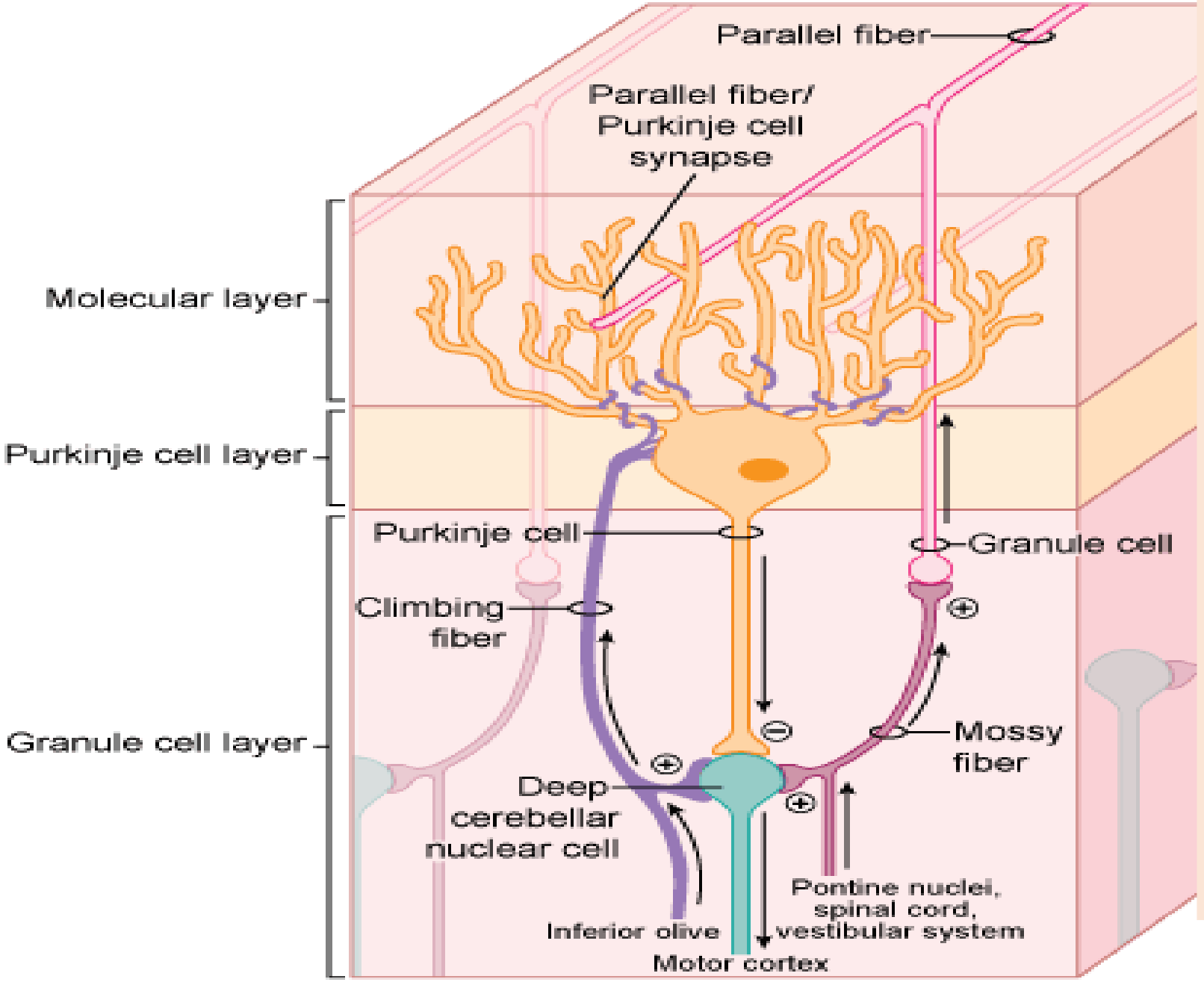
Mechanism:

Controlled through **turn on/off mossy fiber circuit**

Can we perform this movement accurately depending on cerebellar stretch reflex?

- Rapid ballistic movements

- NO
- By turn ON/Off circuits



- Deep cerebellar nuclei are the main cerebellar output
- Deep nuclei are excited by afferent collaterals
- 2 afferents: climbing, mossy fibers
- And inhibited by purkinjie cell fibers
- Normal balance during rest is in favour of excitation, with excitatory signals to cerebral cortex

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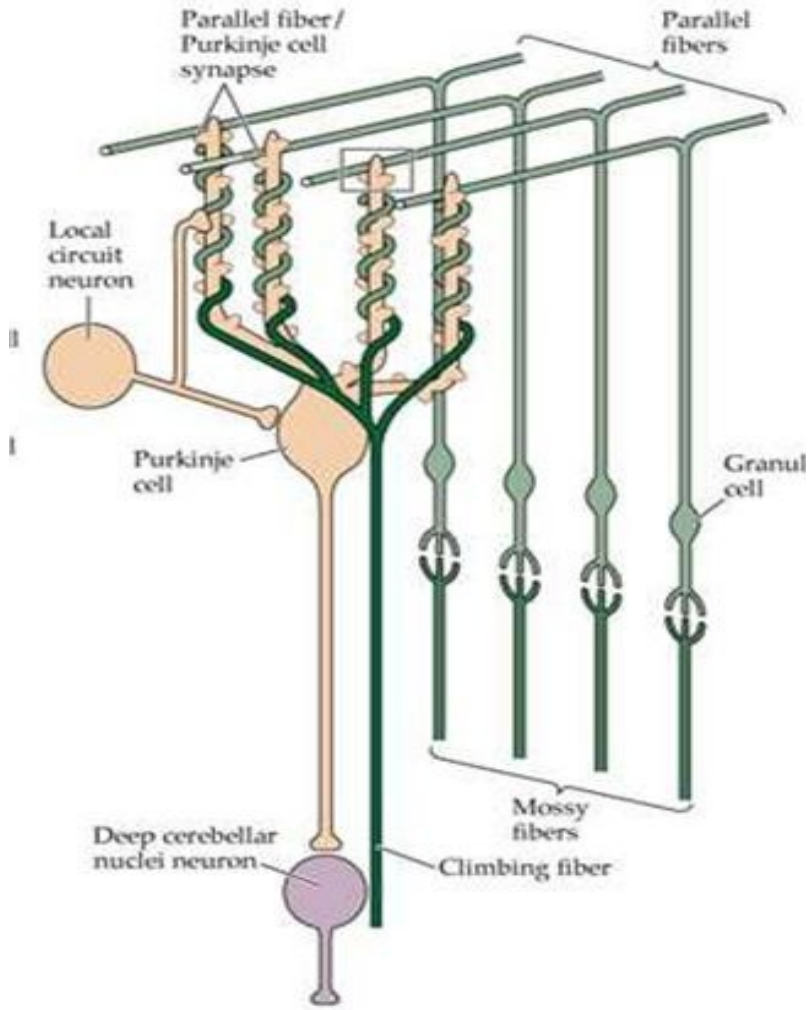
- Cerebellum inputs are 2 types : Mossy fibers and **Climbing fibers**.
- All inputs enter the cerebellum through **Mossy fibers**
- **Except Inferior olivary nucleus**
- **Inferior olivary nucleus send its inputs through climbing fibers**

- **Mossy fibers excite the purkinjie cells in-directly by stimulating hundreds of granular cells**
- Granular cells parallel fibers excite hundreds of purkinjie
- Each parallel fiber input makes a minute input
- **Large number of mossy fibers** must be stimulated simultaneously (spatial summation) to excite the purkinjie cells



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Mossy fiber turn on/off signals and their importance

1- Turn on signals

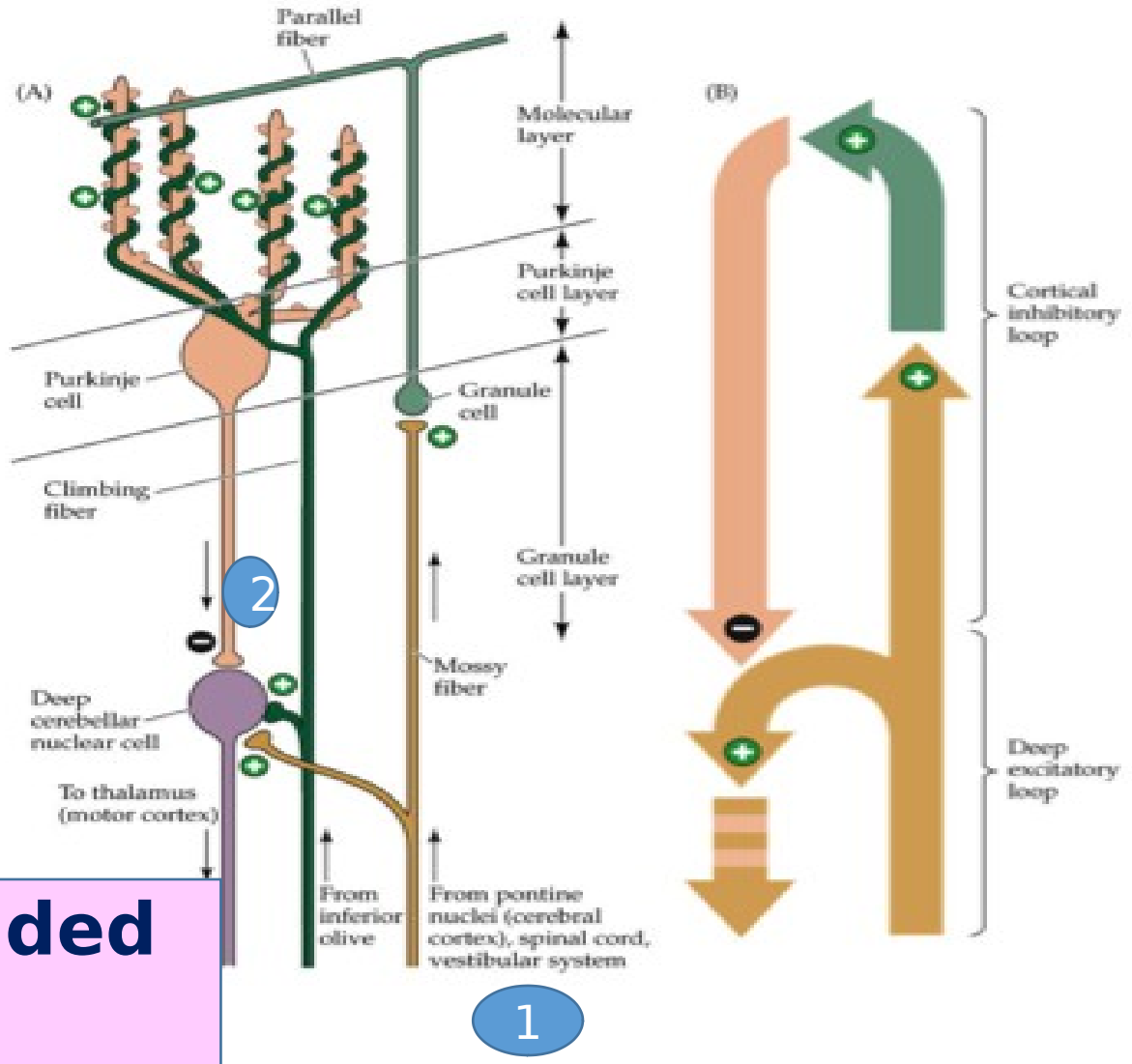
- Cortico-ponto cerebellar mossy fibers carry intended motor plan, stimulate deep nuclei and facilitate movement after few m sec

2-Turn off signals

- Parallel fibers are very slow fibers
- Take time to summate and excite purkinjie cells

So at the end of planned movement

Mossy fibers would have excited granular cells that excite purkinjie cells that inhibit deep nuclei



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Terminate movement at intended time

No overshooting or oscillation

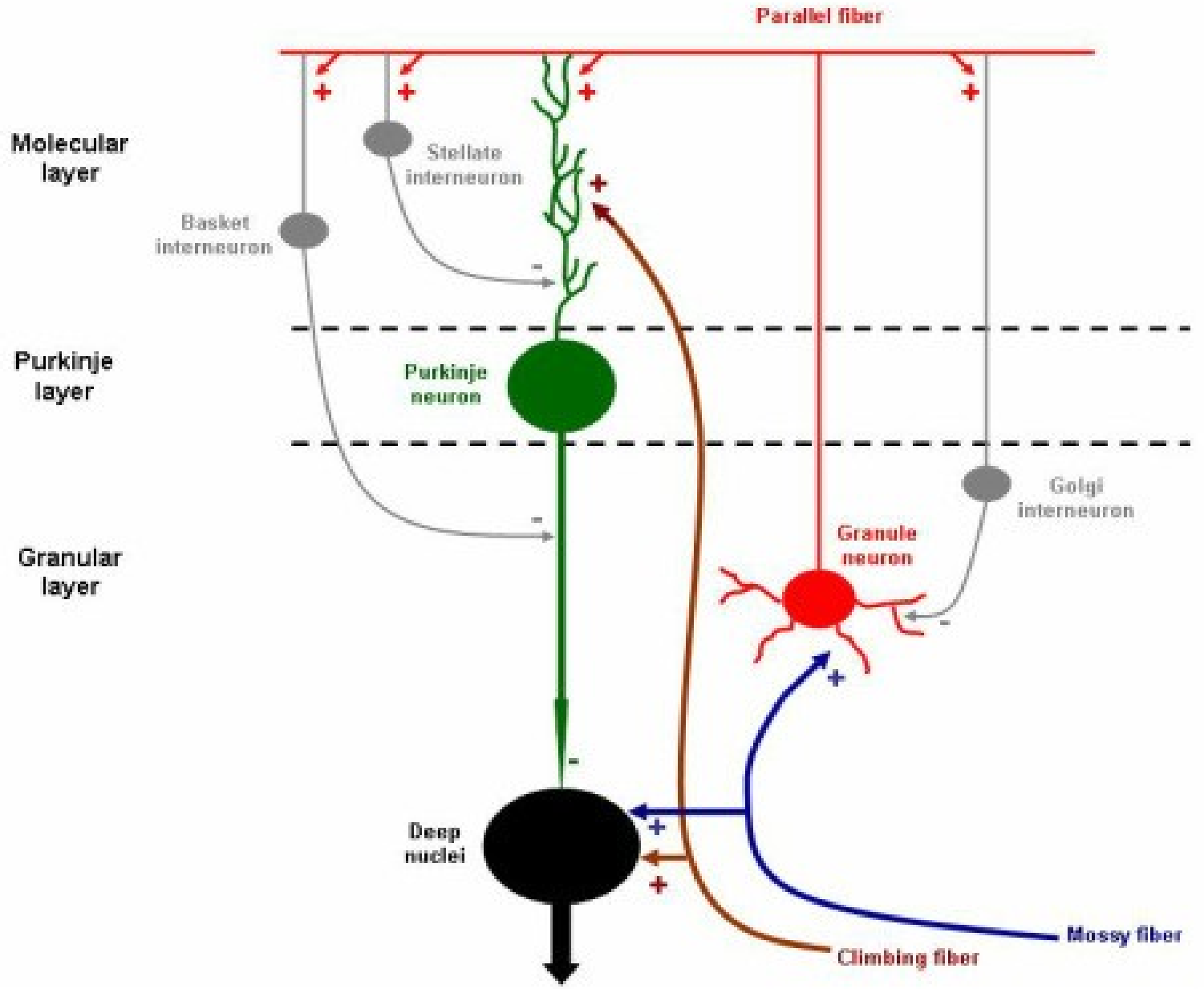
Damping function

- **Negative feedback inhibition:**

Golgi interneurons

- **Negative feed forward inhibition or lateral inhibition:**

Basket cells and



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1. Cerebellar stretch reflex can coordinate rapid ballistic movement
2. Turn on signals are caused by deep cerebellar nuclei stimulation
3. Early deep cerebellar nuclei stimulation is caused by afferent collaterals

1	2	3
No	yes	yes

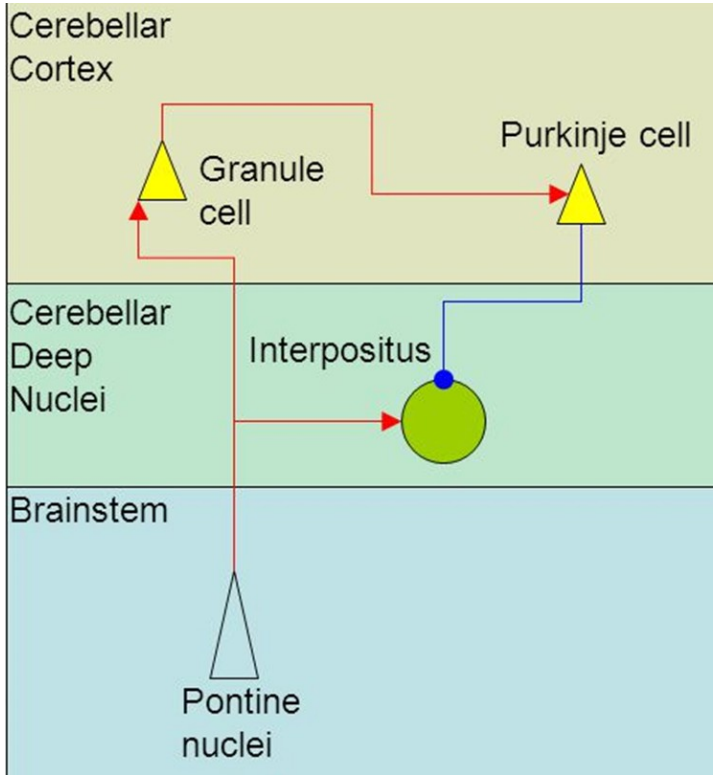
Think together: What causes the turn off signals and why they are delayed than the turn on signals?

Think together: What causes the turn off signals and why they are delayed than the turn on signals?

- Inhibitory signals from purkinjie cells

Delay:

- Parallel fibers (granule cells axons) are slow fibers
- Spatial summation is needed to reach the threshold and excite the purkinjie cell



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Spino-cerebellum lesion

Loss of its Functions:

Coordinate the ongoing movement

- servo-compartor function
- Damping function
- ballistic movement

➢ **overshooting, dysmetria, kinetic tremors**

cerebro-cerebellum Functions

Planning of voluntary movement {feed forward control before action is taken}

a- Planning of sequential movements

-Connected to premotor area, sensory cortex

-Provide plan of sequential movements required to execute intended voluntary movement.

Adjust the final motor command before it is discharged to the lower motor centers.

-Generation of the motor command of the next movement at the same time current movement is still executed.

- Movements progress smoothly and rapidly.

b- Timing of sequential movements

Provide proper timing for each movement

cerebro-cerebellum Functions

Planning of voluntary movement {feed forward control before action is taken}

- **C Prediction: especially in (rapid movements)**
- **Receives**
- Inputs from all sensory organs so it is informed about rate and direction of movement
- **computes**
- change in rate, timing and direction of movement to reach a certain goal at certain time.
- Predict from a changing visual scene how rapidly person approaches an object
- When a person run towards a wall, this function enables him to stop before reaching the wall without hitting it.

- Tennis player meets a coming ball by cerebro-cerebellum

- Goal keeper catches football

Cerebrocerebellum Lesion: movement begin too early or too late, lack of co-ordination, decomposition of movements

Storm your brain, is it true or false?

- Cerebellum perform motor functions only

False

Non- motor function of the cerebellum

Climbing fibers Motor training (learning) :

Inferior olivary nucleus {Error detector}:

Receives:

1- Intended motor plan from motor cortex

2- Actual movement from contracting muscles

Compares both information

Match= normal rate of firing of climbing fibers=1Hz/sec

Mismatch {during training} {learning new task}:

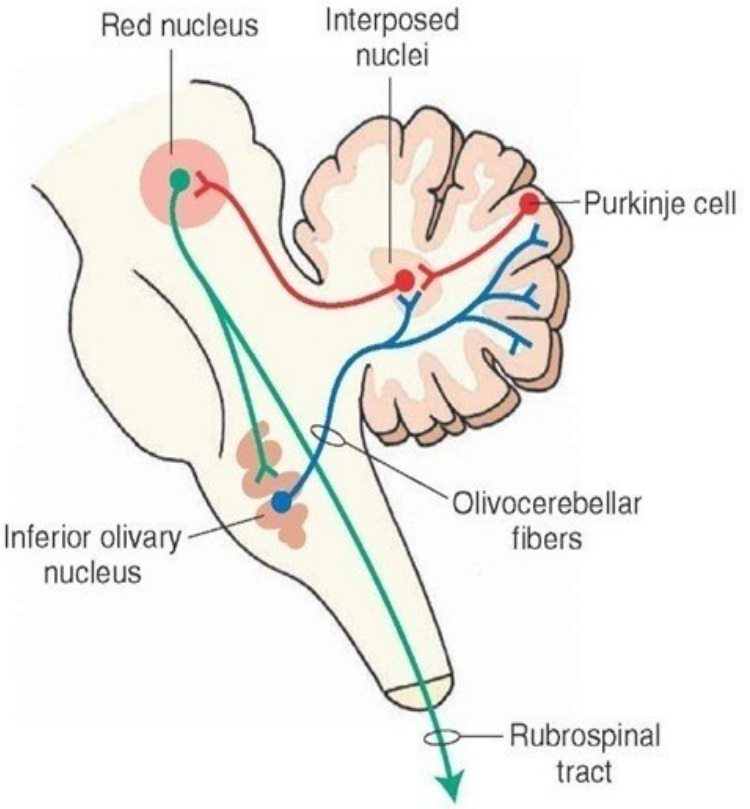
-Particular action goes off target

-Inferior olivary nucleus neurons are activated

Send climbing fibers

- Climbing fibers firing rate increases

- They change the sensistivity of purkinjie cells to parallel fibers



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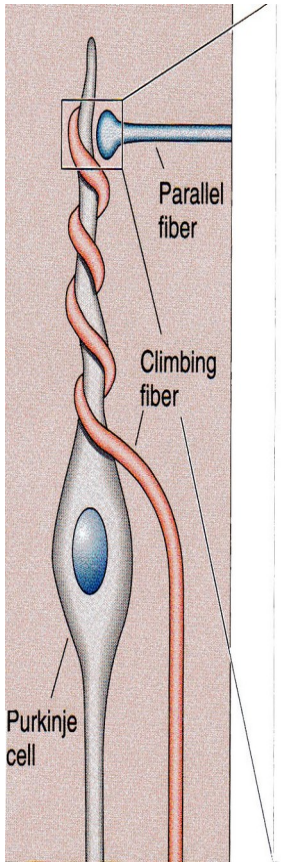
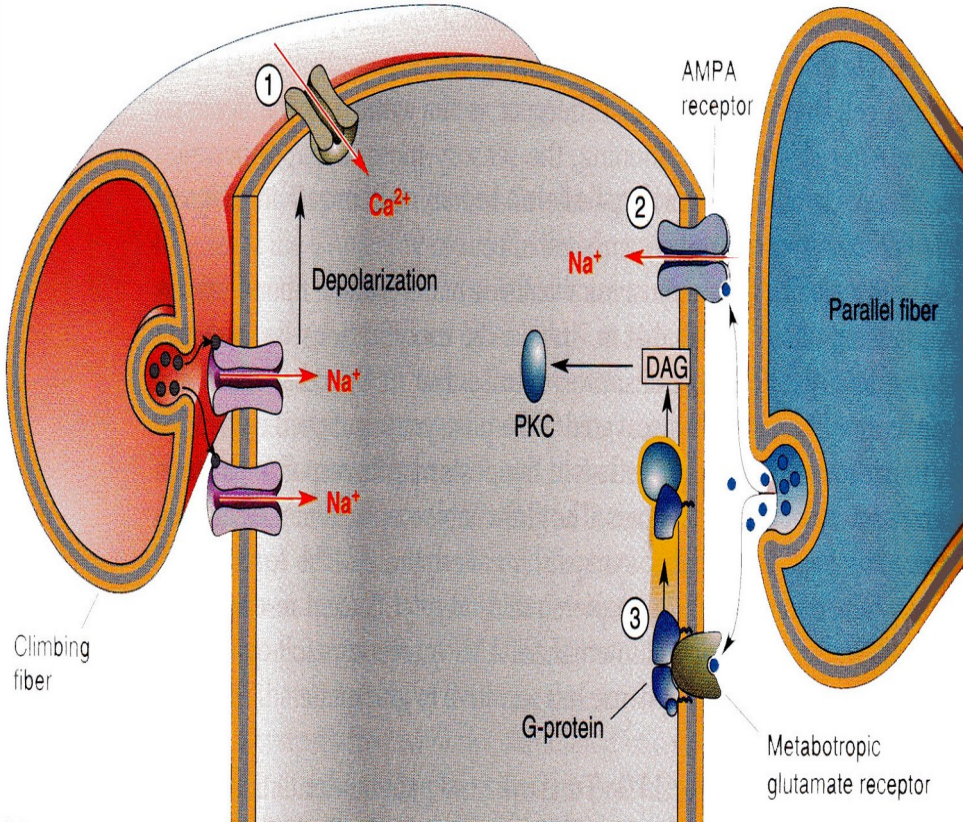
Non- motor function of the cerebellum

Climbing fibers Motor training (learning) :

- They change the sensitivity of purkinjie cells to parallel fibers





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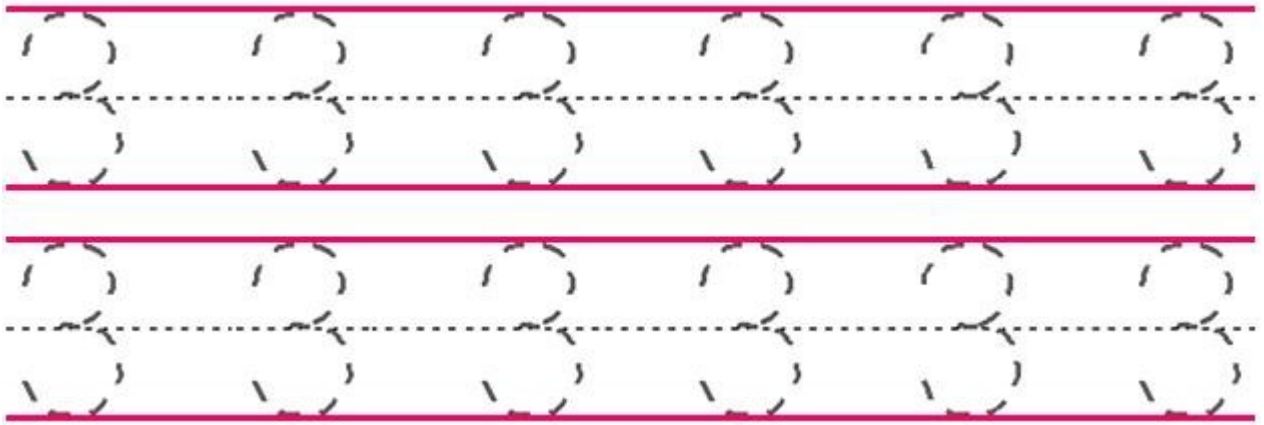
Which fibers are working while learning to write?

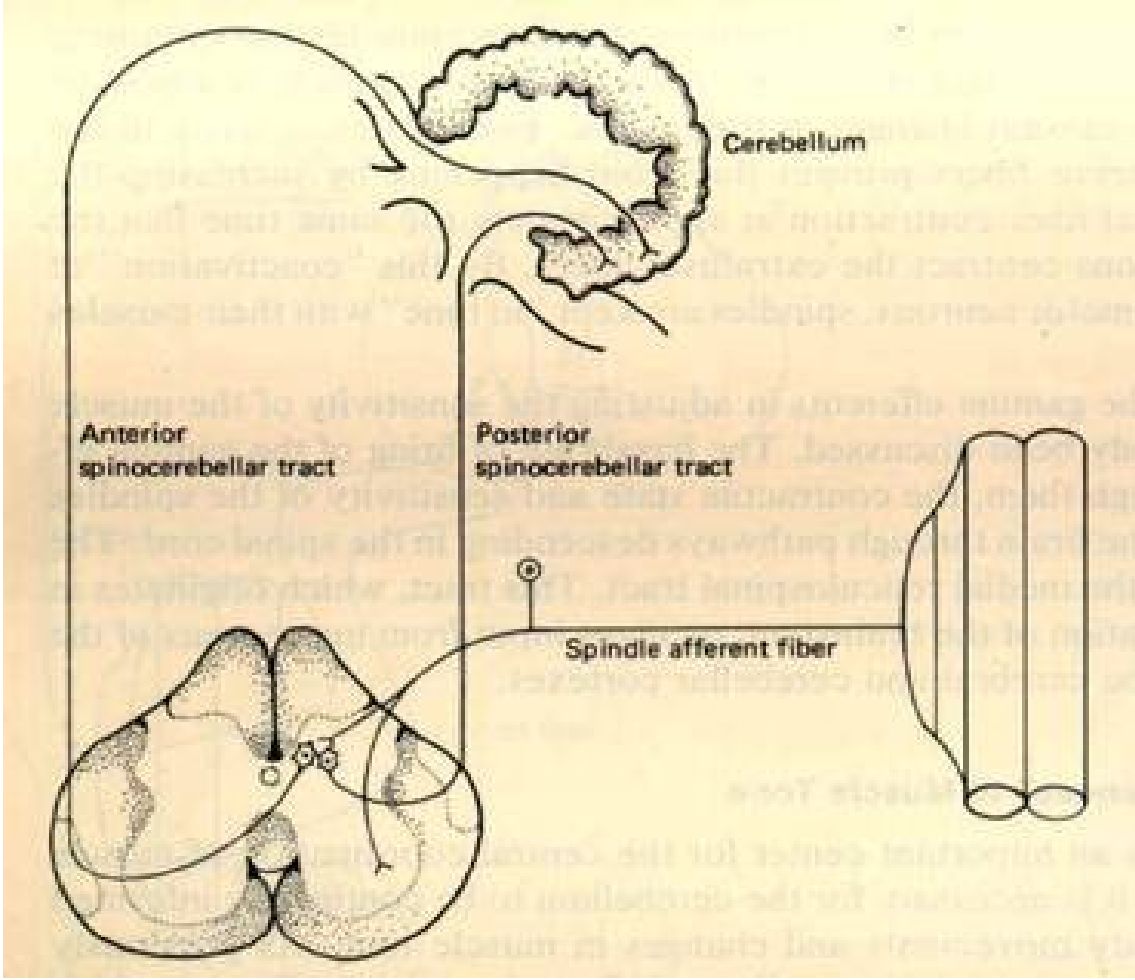


- Inferior olive will detect error
- Inferior olive error send impulses to cerebellum through climbing fibers
- Climbing fibers modulate purkinjie fibers activity
- Motor movement is modulated

Regulation of muscle tone and postural adjustments:

Spinocerebellum inhibitory	Cerebrocerebellum excitatory
The predominant effect is facilitatory so cerebellar lesions lead to hypotonia	

- **<u>Cerebellar stretch reflex:</u>**
- when a contracting muscle meets an unexpectedly load
- **Inputs:** spinocerebellar tracts from muscle spindles
- **Output:** to reticular formation, then reticulospinal and vestibular nucleus then to vestibulospinal tracts that affect γ motor neurons.
- Gives additional support to spinal stretch reflex



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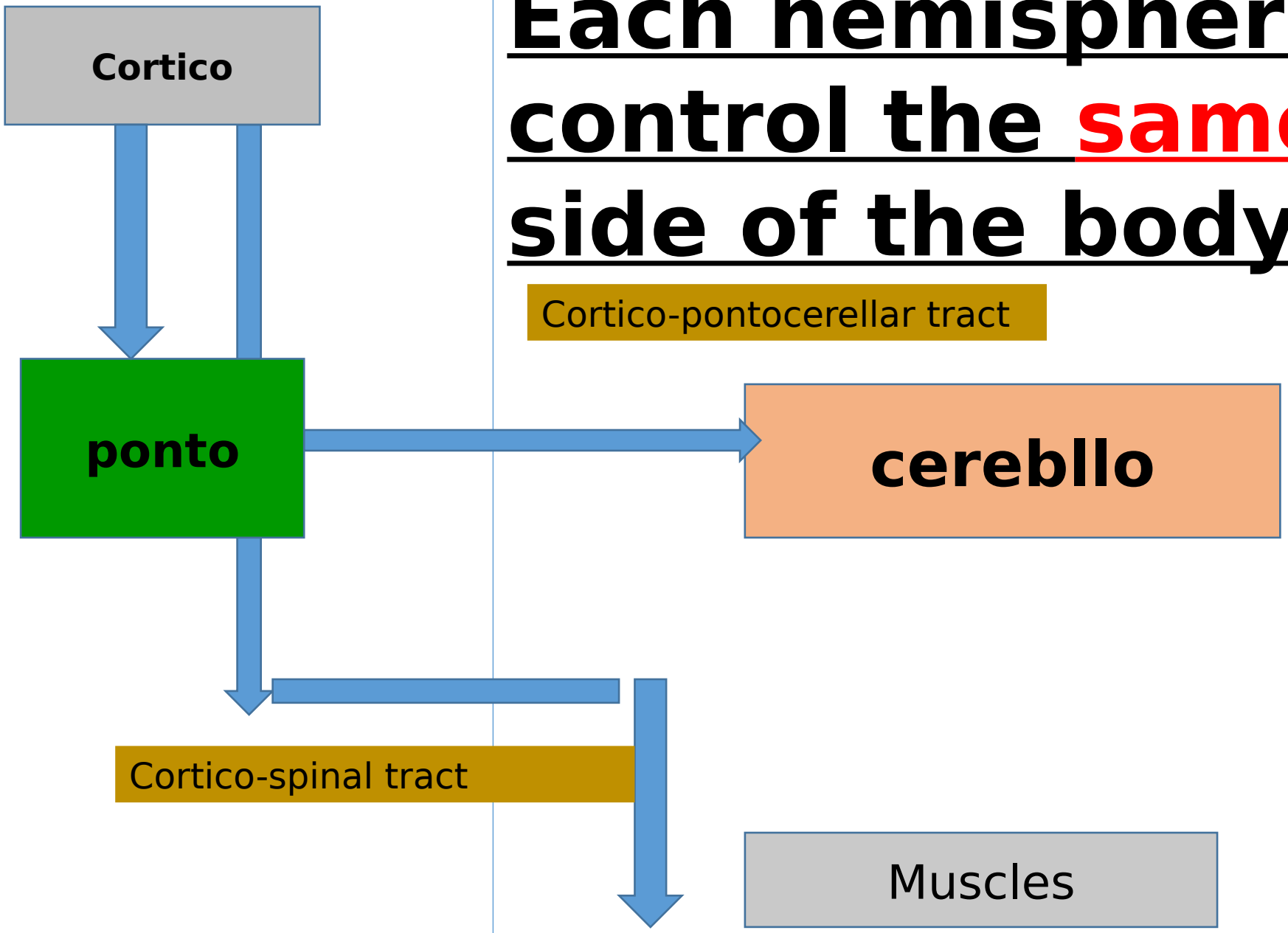
right

left

Each hemisphere control the same side of the body



Summary

Cerebellum functions

- Regulation of body posture, equilibrium
- Servo-comparator function
- Damping function
- Coordination of rapid ballistic movements
- Planning of sequential movements
- Timing of sequential movements
- Prediction
- Regulation of muscle tone and postural adjustments
- Motor learning

Lecture Quiz

- 1---------- fibers rise from inferior olivary nucleus and are important for ----------
- 2- ---------- fibers control rapid ballistic movement
- 3. -----,---------- are cerebrocerebellum functions
- 4- cerebellum controls the opposite side of the body (T or F)

Lecture Quiz

- 1---**Climbing** ---------- fibers rise from inferior olivary nucleus and are important for ----------**learning and motor training-**----
- 2- ---------- fibers control rapid ballistic movement
- 3. ----**planning**-,----**timing** and **prediction** ---------- are cerebro cerebellum functions
- 4- cerebellum controls the opposite side of the body (**F**)

SUGGESTED TEXTBOOKS

1. Ganong review of medical physiology, 26 th edition, chapter 12-. P-569-582
2. Gyton and Hall, 11 th edition, chapter 56, p698-707